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The Truth on the Back of an Envelope.

Empire District Electric Co., Joplin, Mo.

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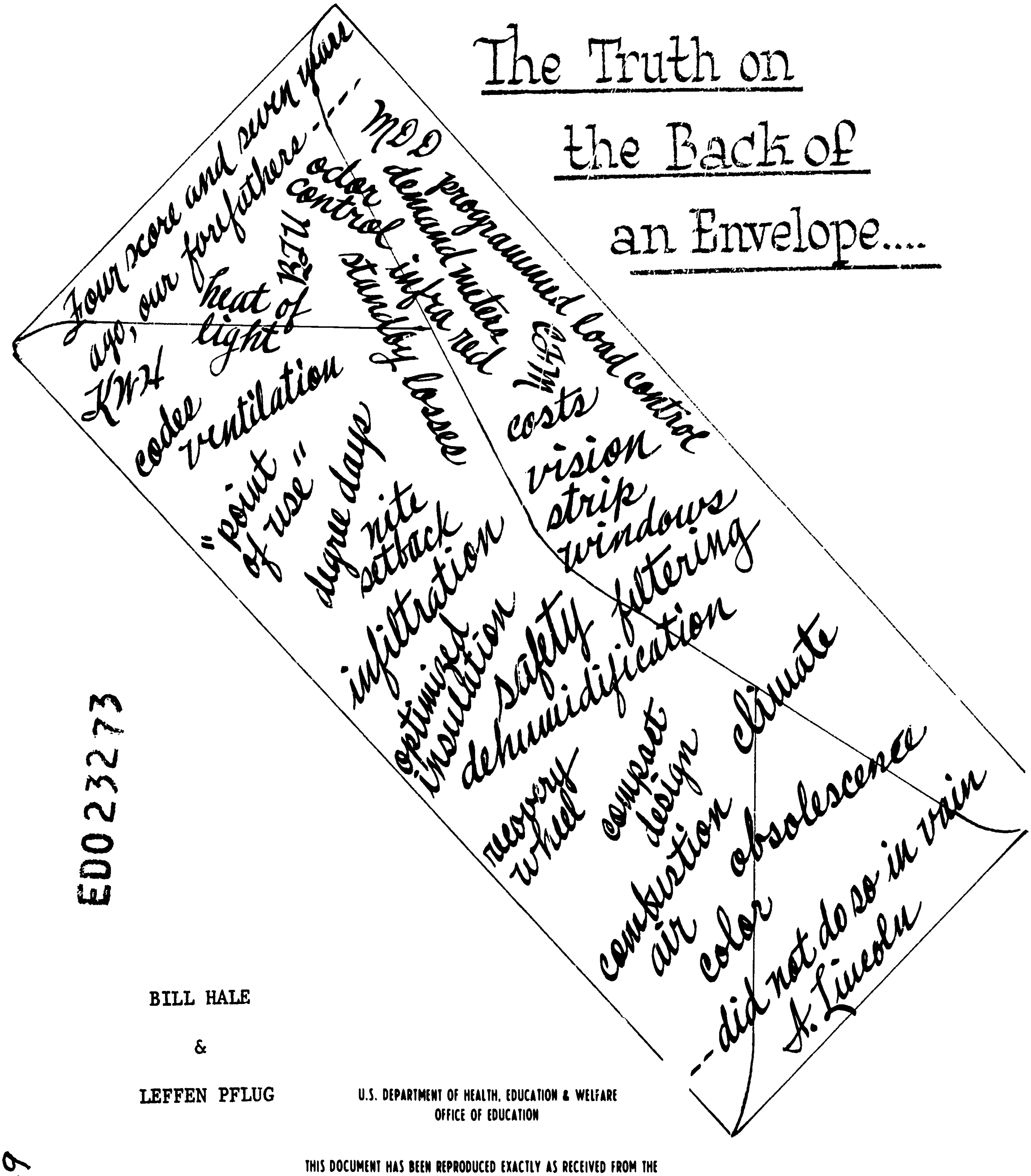
Heating a school electrically is compared with the cost of heating a school by gas or oil. Energy comparisons are shown by actual meters for a full year's operation for 73 schools (20 heated electrically and 53 heated by gas or oil). Metered "unburned" gas per square foot for a year in fuel-fired schools was about 100,000 B.T.U. while the metered energy for heating electrically was about 25,000 B.T.U. Observation of results indicate that the lesser amount of energy used by the electrically heated school was due principally to the response and efficiency of the electric heating equipment. (RH)

The Truth on the Back of an Envelope....



BILL HALE

&

LEFFEN PFLUG

THE EMPIRE DISTRICT ELECTRIC COMPANY

Joplin, Missouri

October, 1966

FOREWORD

The use of electricity for space heating of buildings has become of great importance to many of the more aggressive electric suppliers. The bulk of the heating sales over the last ten years have been made by emphasis on savings in "first cost of equipment" and superior comfort and control of electric equipment. Careful attention to opportunities of extra-ordinary insulation seemed to be the key. The possibility of showing "the lowest cost of owning and operating" by skillful calculation became an accepted sales technique.

As the hard work of the small number of utility sales force assigned to this type of selling began to pay off with substantial numbers of total-electric structures, added personnel were required to meet the needs of our customers.

Some of the "added personnel" brought along experience in industrial and commercial electric use. In this field operating cost estimates were often made by a study of "metered energy" for actual customers engaged in similar kinds of operations. As these "diverted sales engineers", with somewhat less confidence in selling by "benefits, comforts and sometimes intangible advantages", became involved in this sales effort we found that a real need seemed to exist for additional and different information. As we began to assemble "metered energy records" for electrically-heated and gas-fired school buildings, some unexpected and truly remarkable facts became available.

"Truth on the Back of an Envelope" presents these facts as reported to the "Commercial and Industrial Sales Conference" of the Missouri Valley Electric Association on February 11, 1966 in Kansas City, Missouri.

ABSTRACT

"How does the cost of heating a school electrically compare with the cost of heating with gas? (or propane, oil, etc.)". To answer this question forthrightly and accurately would seem to be a reasonably simple assignment!

When a professional engineer examines this question for the first time the information and data available turns out to be a confusing and frustrating conglomerate of claims and counter claims.

(How about the following!)

"Gas costs 1/5 to 1/7th as much as electricity and the installed cost of equipment is about the same."

(Or would you believe this!)

"Electricity can compete with gas on operating cost. The installed equipment cost is substantially less. Electricity gives the lowest owning and operating cost."

"The Truth on the Back of an Envelope" studies first the energy shown by actual meters for a full year's operation for 73* actual schools (20 heated electrically and 53 heated by gas or oil). Metered "unburned" gas per square foot for a year in fuel-fired schools was about 100,000 B.T.U. The metered energy for heating electrically was about 25,000 B.T.U. per square foot for a full year.

Close observation of the results for three nearby schools indicate that the lesser amount of energy used by the electrically heated school is due principally to the <u>response</u> and <u>efficiency</u> of the electric heating equipment. While insulation is a sound economic investment and further reduces the energy used (about 1/3), it is <u>not</u> the major factor we expected it to be.

The electricity used by all 73 of the schools for lighting, pumps, fans, and miscellaneous uses was about 2 to 4 kilowatt-hours per square foot per year (2.5 was typical). This energy amounts to 8,500 B.T.U. for both types of schools.

The bulk of the use of electricity occurs during the 45 to 60 days of coldest winter weather. The control and response of the electric equipment in the spring and fall meets these heating needs with relatively little energy use. One or two "large use months" are normal with electric heating. The importance of this fact is great. Metered energy for the entire year is essential for proper evaluation of the economy of electric heat.

* The data in the appendix shows 74 schools. One set of computer derived estimates is included in the data--this is an air conditioned, electrically heated Kansas City High School--now building. It was included because of local interest.

A close look at the hourly use of energy with fuel-fired heating shows that (1) Much of the heating energy is used when the "lights are out and the kids are gone--at night and over the week-ends", and (2) Significant amounts of energy are used by partially loaded boilers and/or substantial energy is dumped out open windows and ventilators in an attempt to reduce the discomfort of over-heating.

To the energy use, the local price of electricity must be properly applied for a correct comparison. Obviously, the local price of gas (propane, oil, etc.) is also necessary. In southern Missouri a gas-fired school will use about 5¢ worth of gas and 7½¢ worth of electricity which adds up to 12½¢ per square foot per year for these utilities. The cost of energy for the total electric school with resistance heating and normal electric service will be about 13½¢. The use of heat pumps will make it possible to include the energy for air conditioning and still show a cost for these utility services of only 11¢--a lower operating cost than is available by the use of gas.

With gas and electricity directly competitive in today's market, the trend of rates becomes of great importance over the intended life of our new schools. While gas and oil are expected to continue to increase in price, the Federal Power Commission and the electric suppliers are forecasting a 27% decrease by 1980 in the price of electric power.

TRUTH ON THE BACK OF AN ENVELOPE

Two doors west and across 15th Street from my home in Joplin, lives a young optometrist--a real fine neighbor who has an excellent eye practice. He ran for the state senate a few years back--lost, though--to an experienced lawyer-politician--come to think of it--he lost in the primaries! Oh yes, what I started to say was--he's also president of the Joplin School Board.

Me? Oh, I'm in the electric business. Worked for Empire for quite a while. Twenty-five years, they said, when they gave me my service pin with a diamond chip last December! Twenty-five years is quite a while--I remember when we paid a dime for natural gas at the plant instead of the 22¢ we pay for gas now. My job is called industrial sales--mainly with the pipelines, chemicals and large metal processing plants. Interesting work--there's no job quite like it.

Strange thing about the electric business--most all your friends are customers. You sure are asked a lot of questions Anymore it seems most questions are about electric heat. Not long ago, I suddenly realized how little I knew about electric space heating (just like most people in the power business, I guess!)

It was about three years ago when my school board neighbor told me about a school conference in Boston. Apparently the real hot subject was electrically heated schools. "What did I know about this?"

I probably would have taken a whirl at answering that question if he had been a tourist passing through town--but a neighbor--well--I hedged a little bit.

"Our Company serves a couple of electrically-heated schools. Our generation plant burns <u>nine billion cubic feet</u> of gas each year. Why not get some real straight answers from our Plant Engineer and our Sales Department?" I sure did want to give him some information <u>he could count on</u>!

The very next morning, at coffee, I was in luck! At the same table was our power plant engineer, the head of our sales department--and a new sales engineer, just hired a few weeks ago!

It didn't take long for our power plant engineer to state the case simply, "A BTU is a BTU, and our natural gas has 1,000 of them in every cubic foot. Further more, the gas-fired boiler is 80% efficient and everybody knows how many BTU's are in every kilowatt-hour of electricity -- 3,412 BTU's -- right?

"It's just simple arithmetic -- 3,412 is 80% of what? 4,265 BTU's or 4¼ cubic feet of gas! We can still buy 1,000 cubic feet of gas at the plant for 22¢--so 100 cubic feet is only 2.2¢ and 10 cubic feet is only 22/100 of a cent! Instead of 10--we're only talking about 4¼ cubic feet--a cost of less than a mill--less than a tenth of one cent. How can you talk about electricity--even at a penny a kilowatt-hour--when that much gas is more than 10 times as cheap?!?"

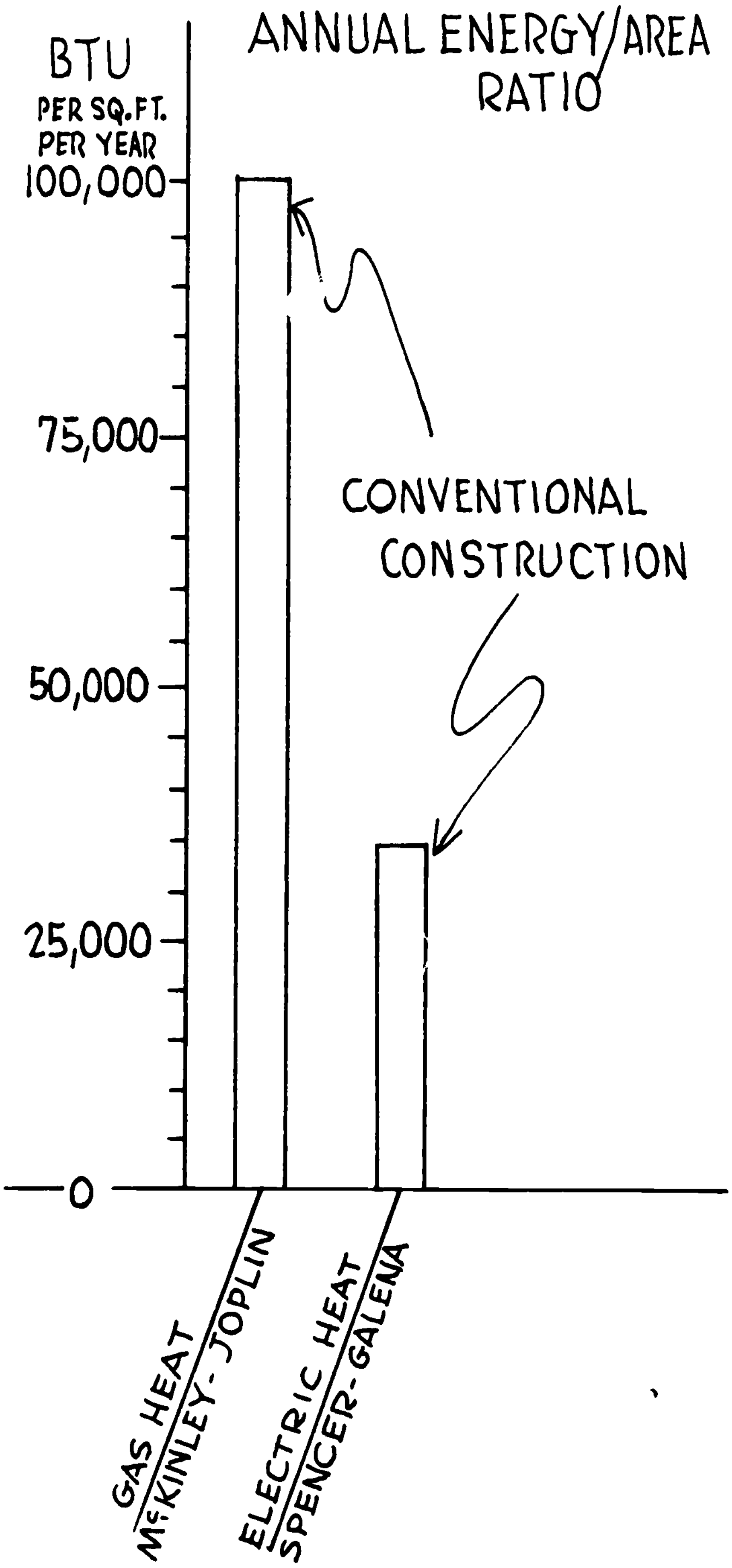
The head of the Sales Department spilled his coffee on the new engineer's sleeve and developed a coughing fit! "OK -- OK, with a heat pump you can get three times the energy--if you use 8/6 and 4 inches of insulation--cut the windows down to vision strips--set the thermostat back to 60°--cut off the outside air--then--if the rate department will waive the demand charge--that'll do it!!"

Anyway--electric units cost less to buy and install--if you use the "present worth" formula--anyone can see that by the 4th year we have them whipped for sure!"

The new recruit blinked--and I hurried away to answer an imaginary phone call.....!

That evening the neighbor's car was stalled, blocking my driveway----so I told him something about an out-of-town customer who had serious electrical troubles--and I sure would get him those answers by the end of the week!!!

Along towards the end of the month (I'd been coming down the alley and parking my car behind my garage) -- I had some real bad luck. I met my neighbor walking up 15th Street! Credit it to luck--quick thinking--or desperation---whatever it was--he and I decided to get the meter readings on gas-fired and electrically heated schools--and find out for ourselves!



Our neighborhood grade school is heated with gas. The meter showed that the gas used for a full year was 2,397,000,000 units of energy (BTU)*. When the school was measured, the floor area was 23,656 square feet for the total school building.

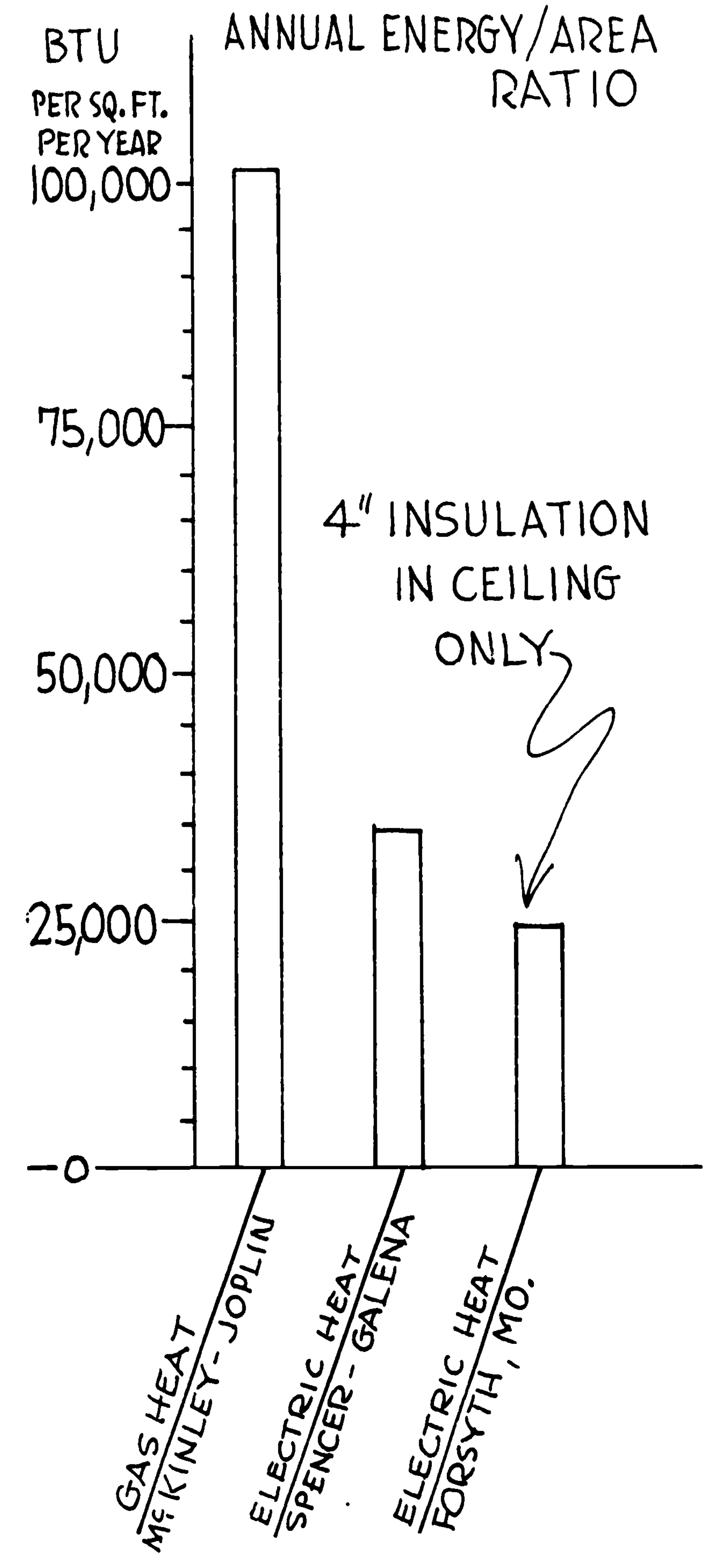
Just like dividing the gallons of gasoline by the miles on the speedometer of your car, we divided the gas energy used by the floor area of the school. Our "gas mileage" turned out to be 101,000 BTU's for the year for each square foot of floor area.

The nearby Spencer grade school is heated electrically. The meters were read for a full year and the building floor area was measured. The electric meter recorded 542,000,000 units of energy (BTU)** and the floor area measured 15,559 square feet. Surprisingly the "electric mileage" turns out to be only 34,800 BTU's for the year for each square foot.

THE METERS WERE READ -- THE SCHOOLS WERE MEASURED. A YEAR'S ENERGY-AREA COMPARISON WAS 101,000 FOR GAS COMPARED TO 34,800 FOR ELECTRICITY. HOW CAN THIS BE TRUE?

* The metered use was 2,397 MCF (same as 23,970 therms) (also the same as 2,397,000 cubic feet) (also the same as 2,397,000,000 BTU). A cubic foot of gas in Joplin has about 1,000 BTU's.

** The metered electric use was 159,360 KwH (which is 542,000,000 BTU).



The usual answer up 'til now has been--

IT MUST BE

INSULATION!!!

The only catch this time was --

NEITHER SCHOOL HAS

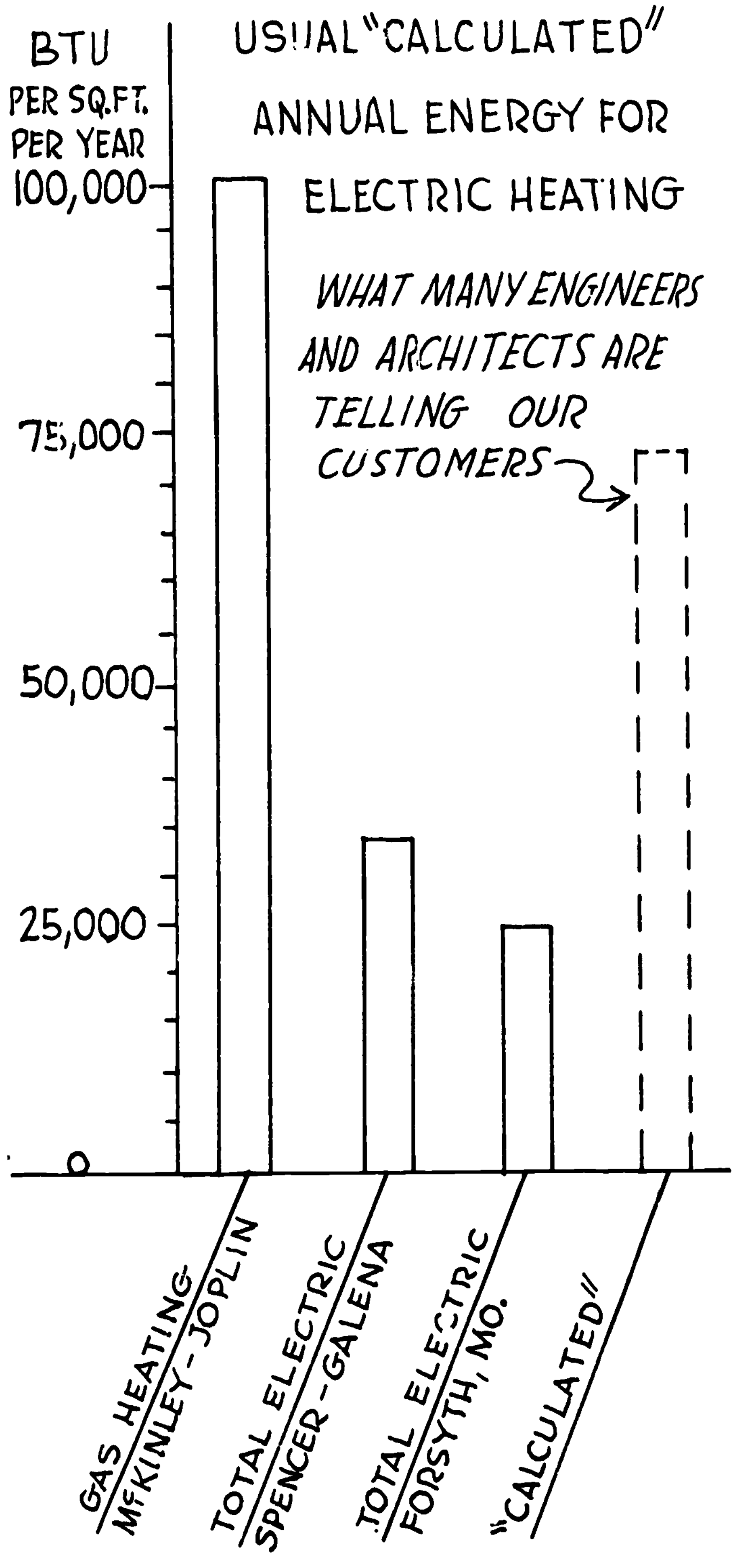
ANY SPECIAL INSULATION!!!

x x x x x x x x x x

A $14,000 gas line caused the Spencer school to use electric equipment in place of the gas units. This was a straight substitution!!!

INSULATION IS IMPORTANT as we learned when the next electric school was built at Forsyth. With 4" of insulation as the only special insulation, the energy use dropped to 24,400 units.

30% less energy was needed when ceiling insulation was included in the design.



One robin doesn't make a spring

<u>B U T</u>

<u>IF</u> the gas and electric meters and the actual floor area for all schools fit this pattern---

#1. Many ARCHITECTS and ENGINEERS have signed reports for their clients containing a GROSS <u>ERROR</u> of 200-300%.

#2. The use of "CALCULATED ELECTRIC ENERGY NEEDS" by gas utility companies in direct contradiction to metered data is

<u>FALSE ADVERTISING</u>

even if unintentional!!!

OVER 200% ERROR

A N D

FALSE ADVERTISING

are

STRONG

STATEMENTS

to be based on a

Big "If"

! ! ! ! ! ! ! ! ! !

Let's measure the buildings

and

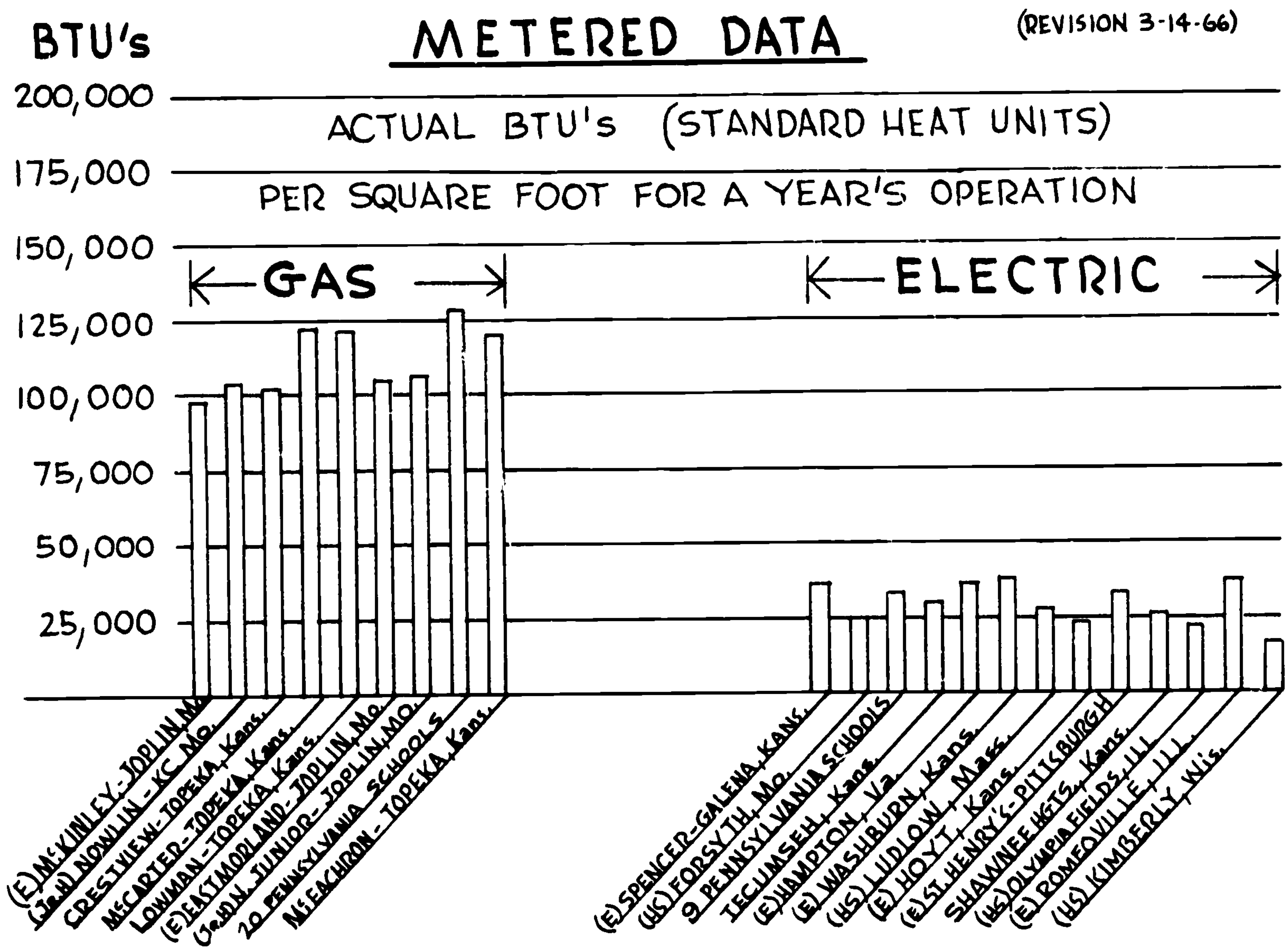
read the meters

a t <u>L O T S</u> <u>O F</u> <u>S C H O O L S</u>

HERE ARE THE RESULTS
FOR 20 SCHOOLS

METERED DATA BAR CHART

20 SCHOOLS



(3) With tape measures and meters at three SCHOOLS

--- A N E X C I T I N G P O S S I B I L I T Y ! ! !

(20) Floor area and meter readings (above) for 20 SCHOOLS pointed to ---

--- A M O S T I M P O R T A N T P R I N C I P L E ! ! !

(7 4) More meters and measurements for over 74 SCHOOLS (Appendix pages
+
2 and 3) provides ---

--- T H E O V E R W H E L M I N G C E R T A I N T Y

of a massive volume of data on actual schools!!!

THE GOSPEL ACCORDING TO ST. YOPP

The simple truth is "ELECTRICITY IS A REFINED SOURCE OF ENERGY--EASILY CONTROLLED--INSTANTLY AVAILABLE, IN ANY AMOUNT, AT ANY PLACE, AT THE <u>PRECISE</u> <u>TIME</u> <u>NEEDED</u>".

So says Harry T. Yopp of Atlanta, Georgia in his 1964 book "Electricity vs Fossil Fuels". This remarkably clear, extremely able presentation of the "ALL-ELECTRIC concept of commercial buildings" is a MUST for any person who aspires to work with modern buildings.

METERED DATA -- actual operating records from the gas and electric meters are, by far, the most ACCURATE, PRACTICAL AND SATISFACTORY source of operating information.

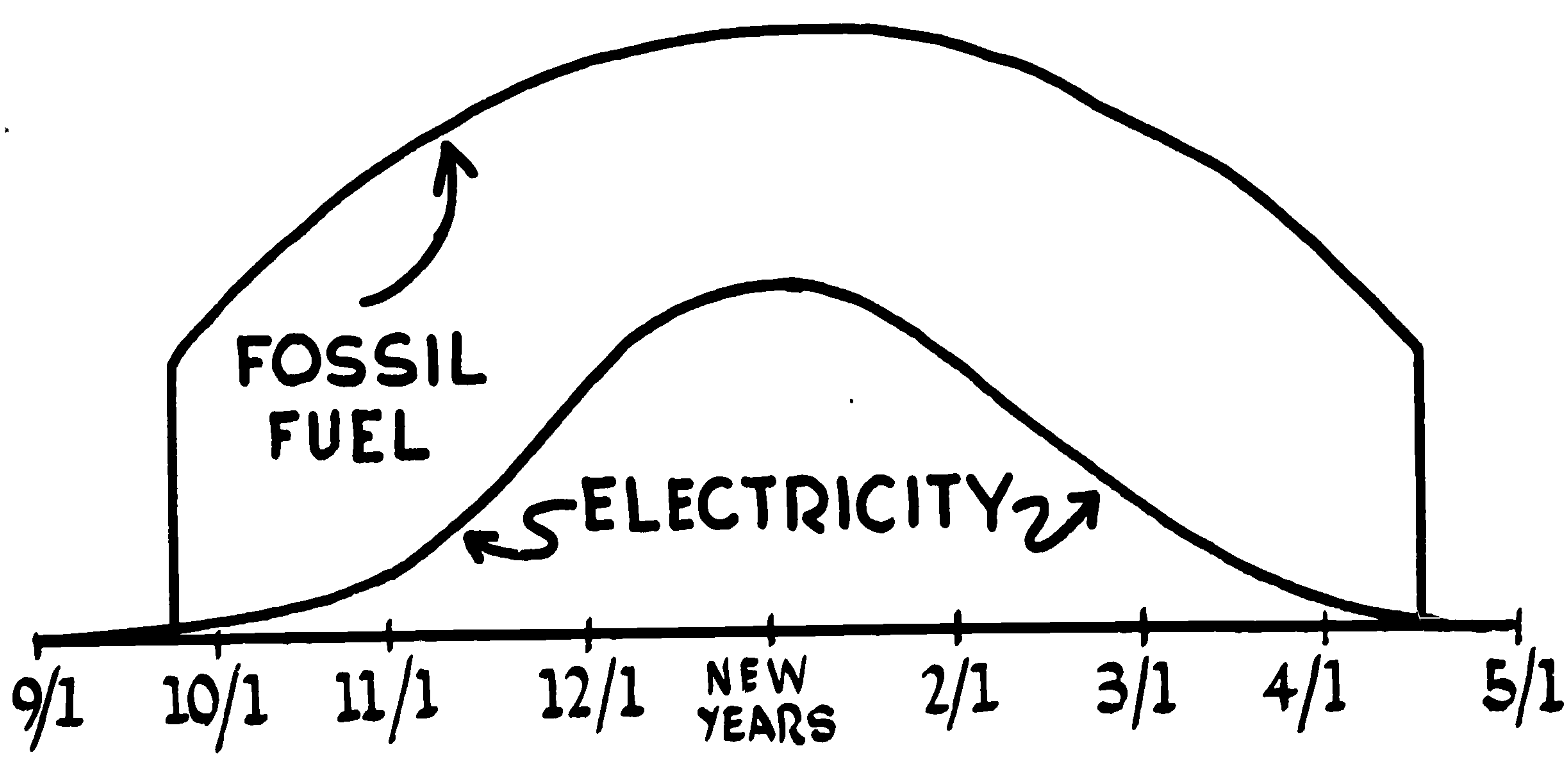
An understanding of the characteristics of electric energy and a realization that metered records on actual buildings are the seeds of a TREMENDOUS BREAKTHROUGH in the use and sale of electric power.

One of the real puzzles of electric use for heating is the "HIGH BILL". The unique ability of electricity to meet the heating needs precisely--means--

WHEN THE WEATHER IS COLD -- BY FAR THE <u>LARGEST</u> <u>PERCENTAGE</u> OF THE YEARLY ENERGY USE TAKES PLACE.

This sounds logical enough -- but the dramatic difference is best shown by the month by month gas and electric meter readings at our test schools.

<u>How Heating Energy Is Used</u>

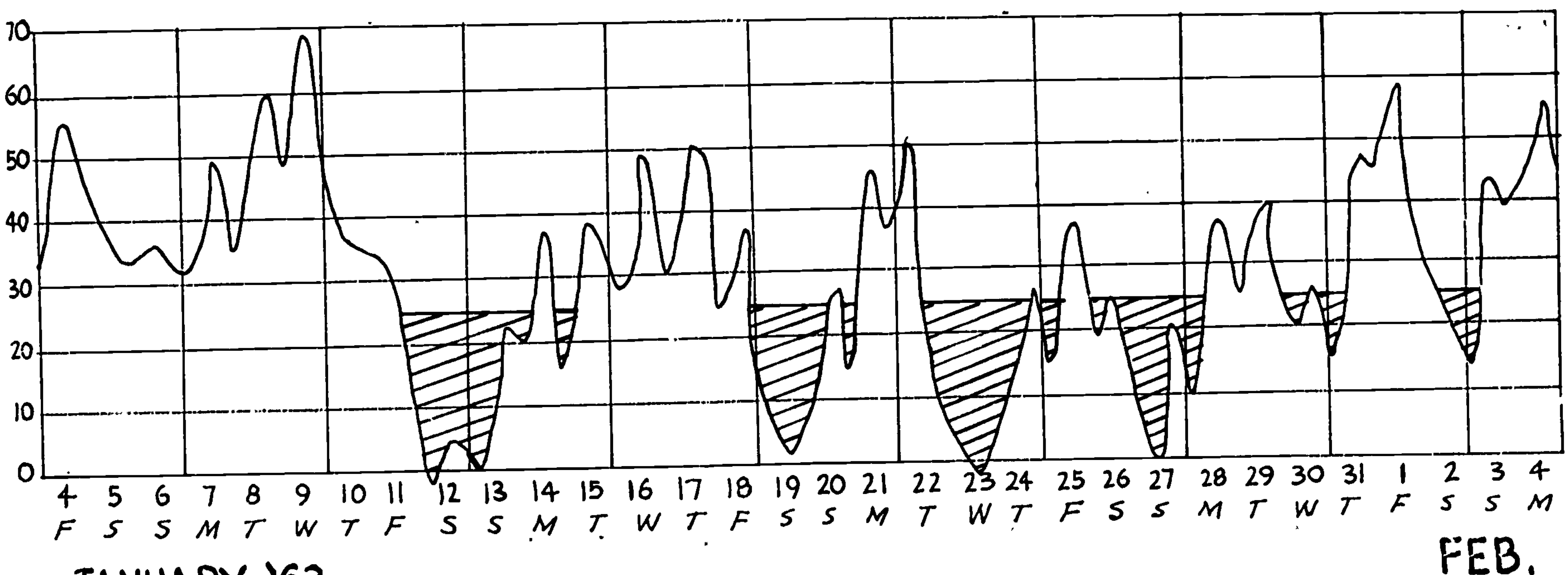


DO YOU LIKE SURPRISES??

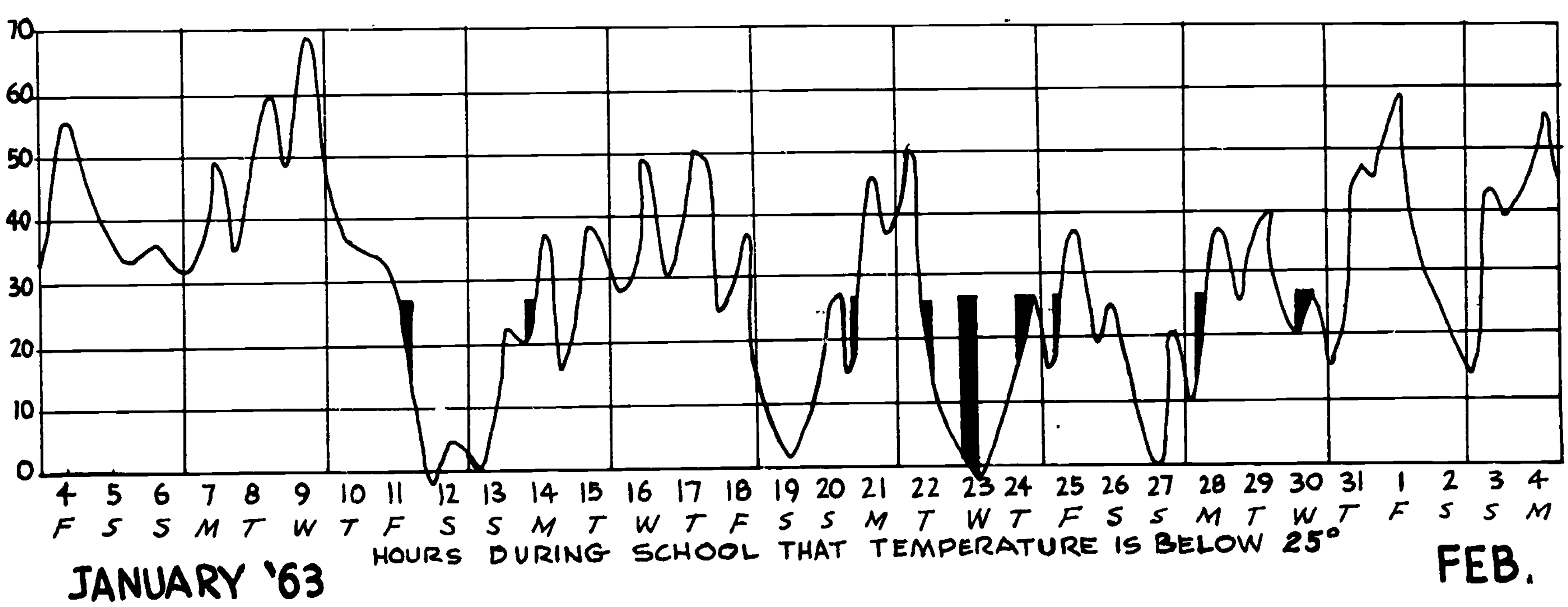
A recent study of a typical 30 pupil classroom with a modern lighting design shows---

THE HEAT FROM 30 KIDS plus HEAT FROM MODERN LIGHTS	is greater than >	HEAT LOSS OF A SCHOOL at 25° F. AND ABOVE

Here's the most severe weather in recent years



How much of the time is school in session?



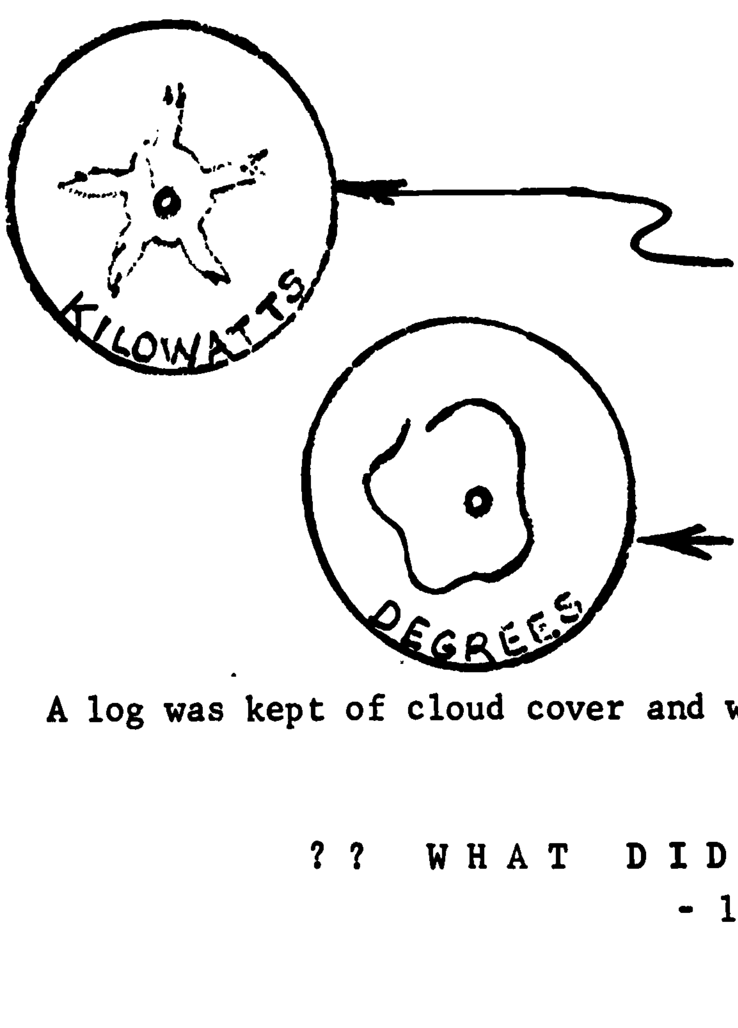
Total hours = 31 days x 24 hours = 744 hours (100%)
Total hours when temperature is below 25° F. = 424 (57%)
Hours during school when temperature is below 25° F. = 72 (10%)

OVER 3/4 OF THE ENERGY OF A GAS FIRED SCHOOL is used when "THE KIDS ARE AT HOME" and the "LIGHTS ARE OFF" -- OVER NIGHTS and OVER WEEK-END!

THEN ONE MORE TEST ! !

We hired a spy from the 7th grade . . .

Her sole duty -- to go out in the cold -- AND READ THE GAS METERS AT 2 SCHOOLS -- before and after each school day -- FOR 2 MONTHS



RECORDING METERS WERE INSTALLED AT SPENCER AND FORSYTH TOTAL-ELECTRIC SCHOOLS.

TEMPERATURE WAS RECORDED CONTINUOUSLY.

A log was kept of cloud cover and wind velocity . . .

?? WHAT DID WE FIND ??

WE'VE BEEN CONNED INTO ANSWERING THE WRONG QUESTIONS

The question of "How is it possible for electric energy to heat a school with only O N E - T H I R D the BTU's?" has many interesting answers ---- However . . . .

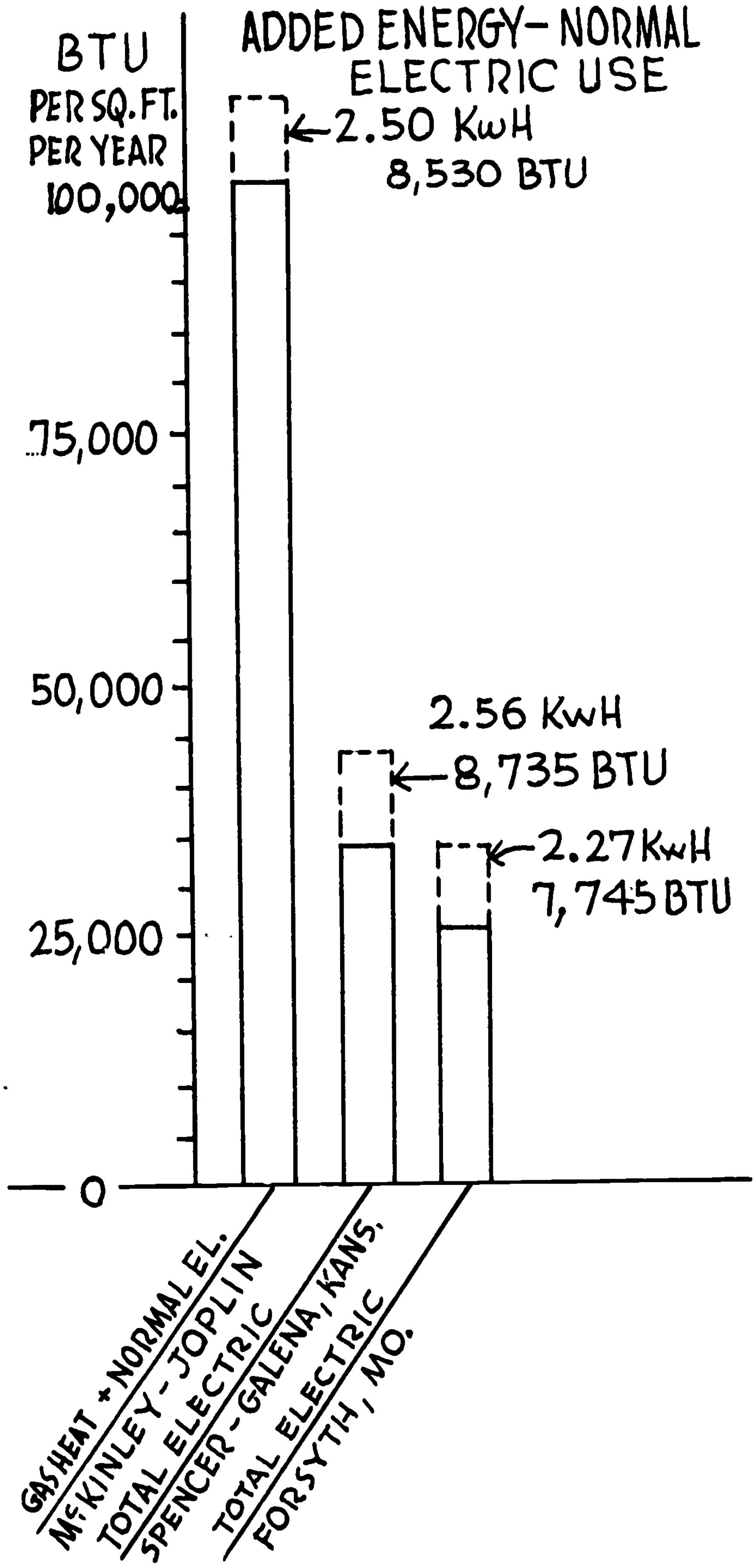
THE IMPORTANT QUESTION IS

With only 25,000 BTU's of electric energy needed for superior school comfort, WHY DOES GAS TAKE 3 or 4 TIMES AS MUCH? ? A few of the many reasons are ----

* The BTU's in "unburned" gas has very little to do with the school heat loss and student comfort.
* Many BTU's go up the flue at all times when gas is burned.
* Overall annual efficiency is far less than the 70 to 80% claimed!!
* The need for a little heat is met by "firing up the system"-- a lot of energy is used to meet a small energy need--the unnecessary energy is wasted (out the ventilators or open windows).
* The response to sudden change is horribly slow! Kids arriving, sudden sunshine, wind shift and temperature change--by the time the usual gas system can respond -- the needs have probably changed!

HOW MUCH OTHER ENERGY IS USED FOR NORMAL ELECTRIC SERVICE?

(Lighting, Cooking, Fans, Etc.)



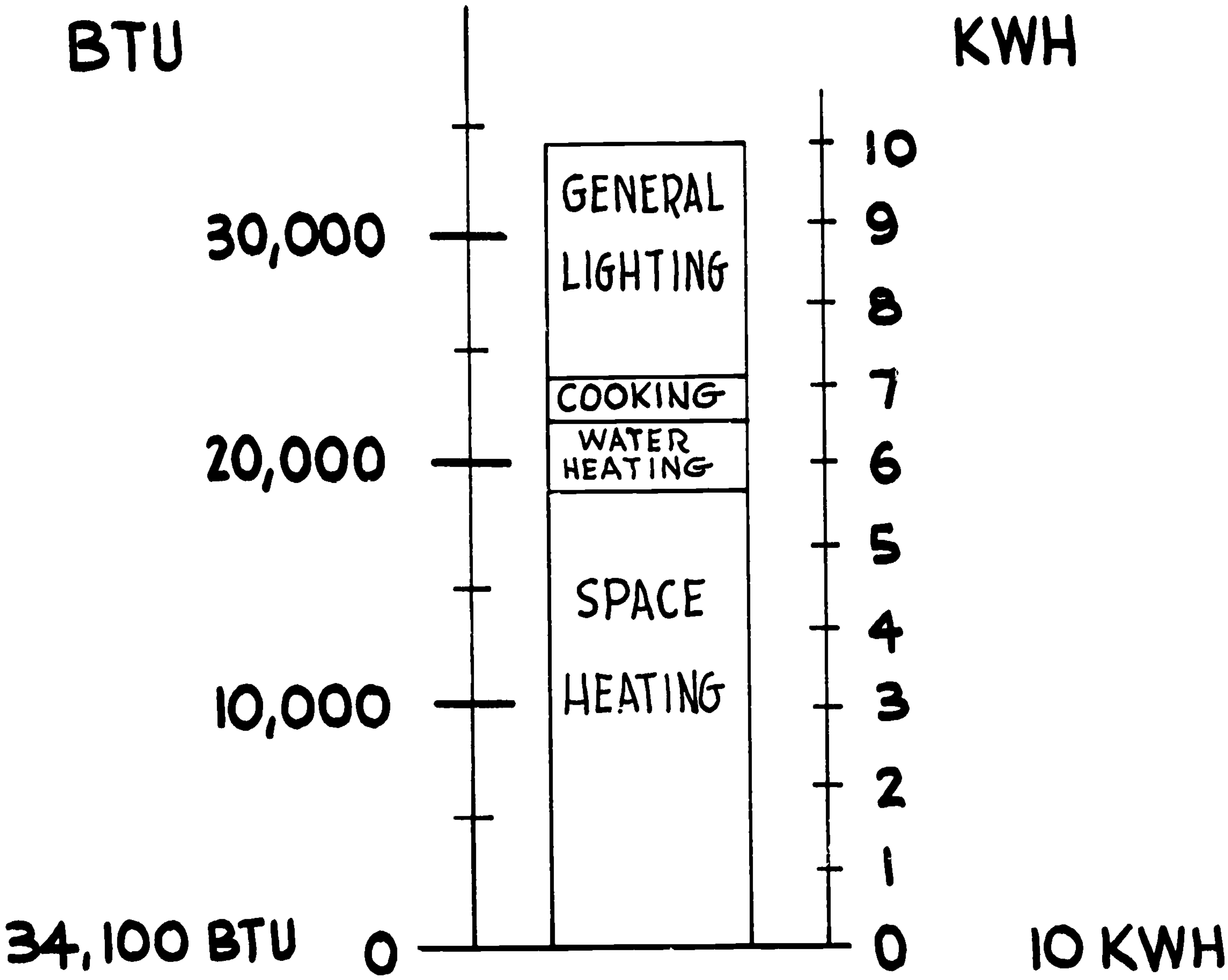
There is much to be learned about schools. For instance, the energy for lighting and incidental operation of fans and pumps is nearly always supplied by electricity. Since electric meter readings are available, the energy for these functions is easy to study.

2½ kilowatt-hours (which is 8,500 BTU) is the typical amount of energy for a school year for each square foot of floor space.

x x x x x x x x x x

When many schools are studied--a range of energy use between 7,000 and 10,000 BTU (which is about 2 to 4 KwH) is the "RANGE OF REASON"!

WHAT IS THE TRUTH ABOUT ENERGY FOR A TOTAL-ELECTRIC SCHOOL??

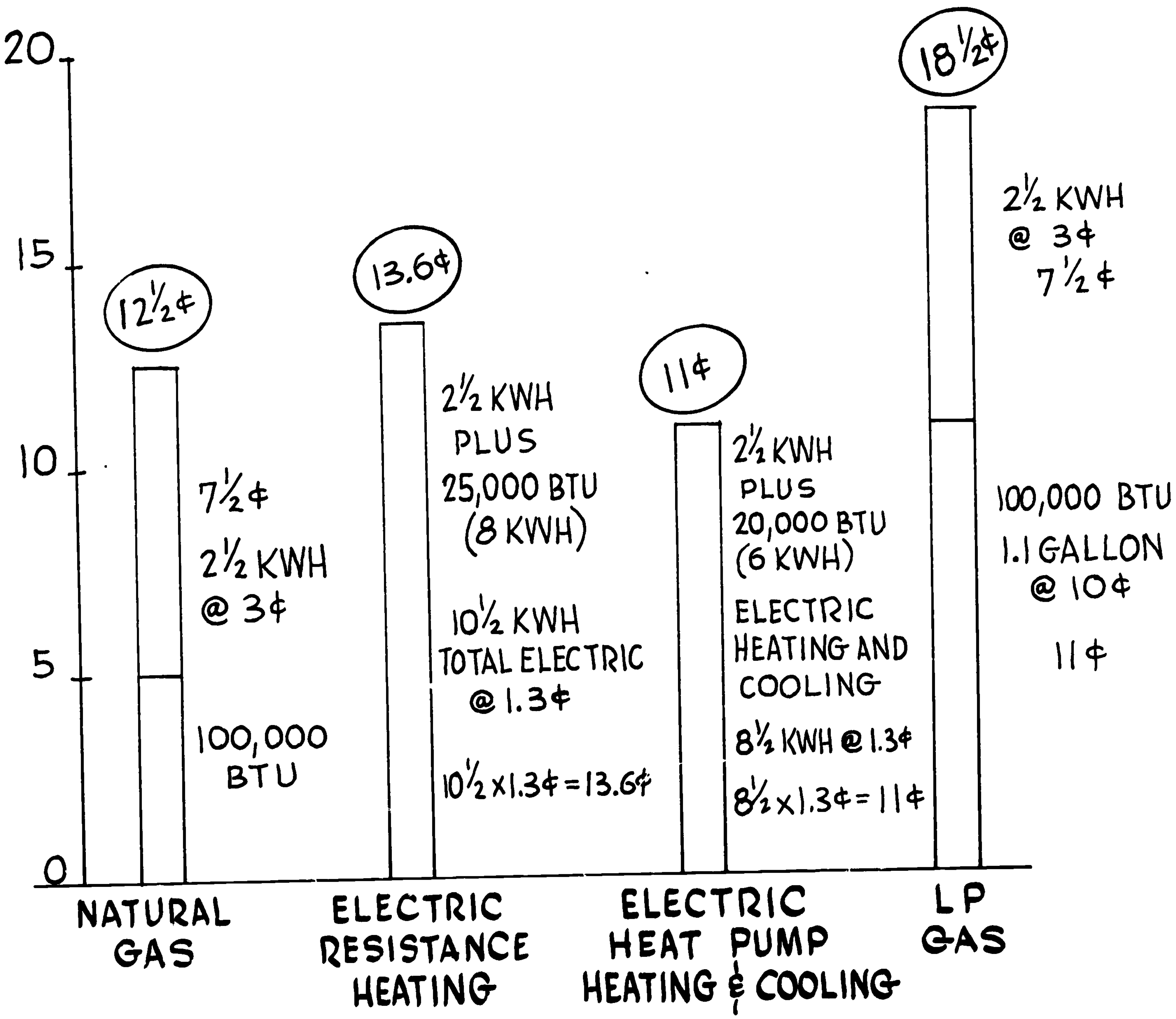


SEPERATE METERS ON LIGHTING, COOKING, HOT WATER USE, AND SPACE HEATING ON AN ACTUAL SCHOOL---SHOWN ABOVE.

The RANGE OF REASON -- For 30 SCHOOLS

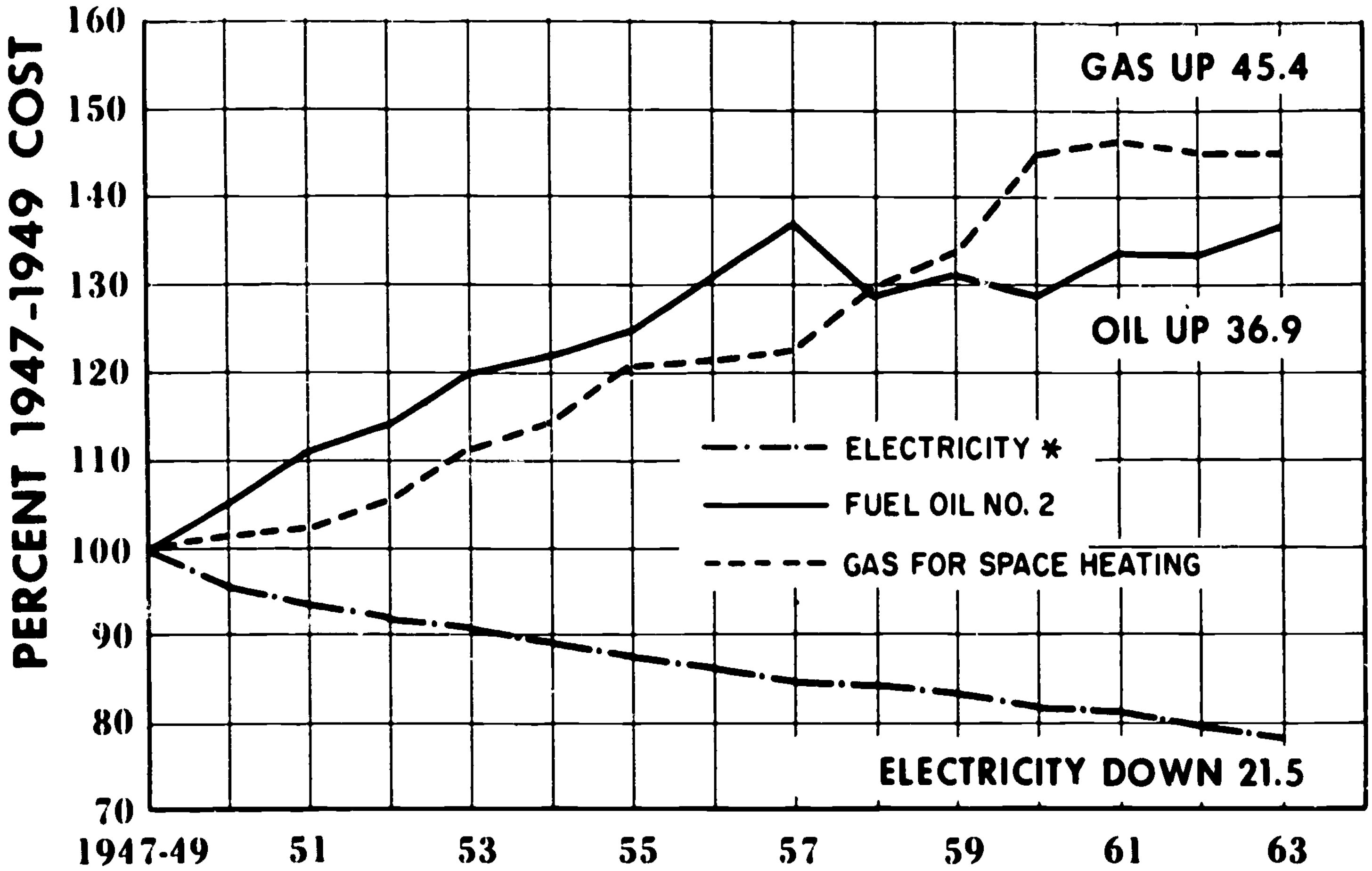
	Energy in KwH			Energy in BTU		
	From	To	Typical	From	To	Typical
General Lighting	2.0	4.0	2.5	6,800	13,600	8,500
Cooking	0.4	0.6	0.5	1,400	2,000	1,700
Water Heating	0.5	1.2	1.0	1,700	4,000	3,000
Space Heating	5.3	8.2	6.0	18,000	28,000	20,900
	8.2	14.0	10.0	27,900	47,600	34,100

YOU CAN'T PAY UTILITY BILLS WITH BTU'S.



GAS HAS NO IMPORTANT COST ADVANTAGE TODAY

WHAT ABOUT TOMORROW ? ? ?



SOURCE:
FOSSIL FUELS
U.S. DEPARTMENT OF LABOR
BUREAU OF LABOR STATISTICS
ELECTRICITY
EDISON ELECTRIC INSTITUTE

* NOTE:
ELECTRICITY IS COST/KW-HR TO RESIDENTIAL CUSTOMER BASED ON AVERAGE MONTHLY USAGE OF ELECTRICITY IN THE HOME.

FEDERAL POWER COMMISSION FORECAST ELECTRIC COST

DOWN

27%

BY 1980 (14 YEARS)

THE REAL

"TRUTH ON THE BACK OF AN ENVELOPE"

is

* TOTAL ELECTRIC SCHOOLS HAVE THESE UNIQUE ADVANTAGES:

1. A new concept of comfort -- no overheating.
2. Usually lower cost to buy and install.
3. Less maintenance expense.
4. Equivalent direct operating cost.
5. Wiring for electric heat means circuits are adequate for air conditioning -- now or later.
6. Usually gives more useful space -- no vents, chimneys or boiler rooms.
7. Much safer.
8. Noticeably cleaner -- less redecorating needed.
9. Simple, effective and inexpensive controls.
10. In more and more states -- lower insurance costs.
11. Protection against rising gas costs. Electric power generation has a choice of fuels -- oil, atomic energy or coal can be used instead, if gas prices continue to rise!

AND THIS IS JUST THE BEGINNING -- COMPETENT ELECTRIC DESIGN WILL OFFER

--Added economy and comfort with heat pumps and compound heat pumps,

--Heat recovery cycles such as "heat of light", thermal louvers, recovery wheels for exhaust air,

--Humidification and dehumidification

--Air Filtering

--Draft barriers

AND MANY OTHERS.

A P P E N D I X

Page

A-1 Gas Primer

A-2 Yearly Energy--Area Ratios for 74 Schools.

A-4 "In-Classroom Gas" compared to "Point-of-Use" Electric

A-5 5-Ton Gas Air Conditioner vs. 5-Ton Electric.

Gas Primer

1,000 BTU is about one cubic foot
100,000 BTU is 100 cubic feet
(Also called one therm)
1,000,000 BTU is 1,000 cubic feet
(Also called one MCF)

TYPICAL RATE
50¢ per MCF
same as
50¢ per therm

REASONABLE RANGE – 1966
4¢ to 8¢ per therm

Firm rates are higher
than interruptible (say 20%)

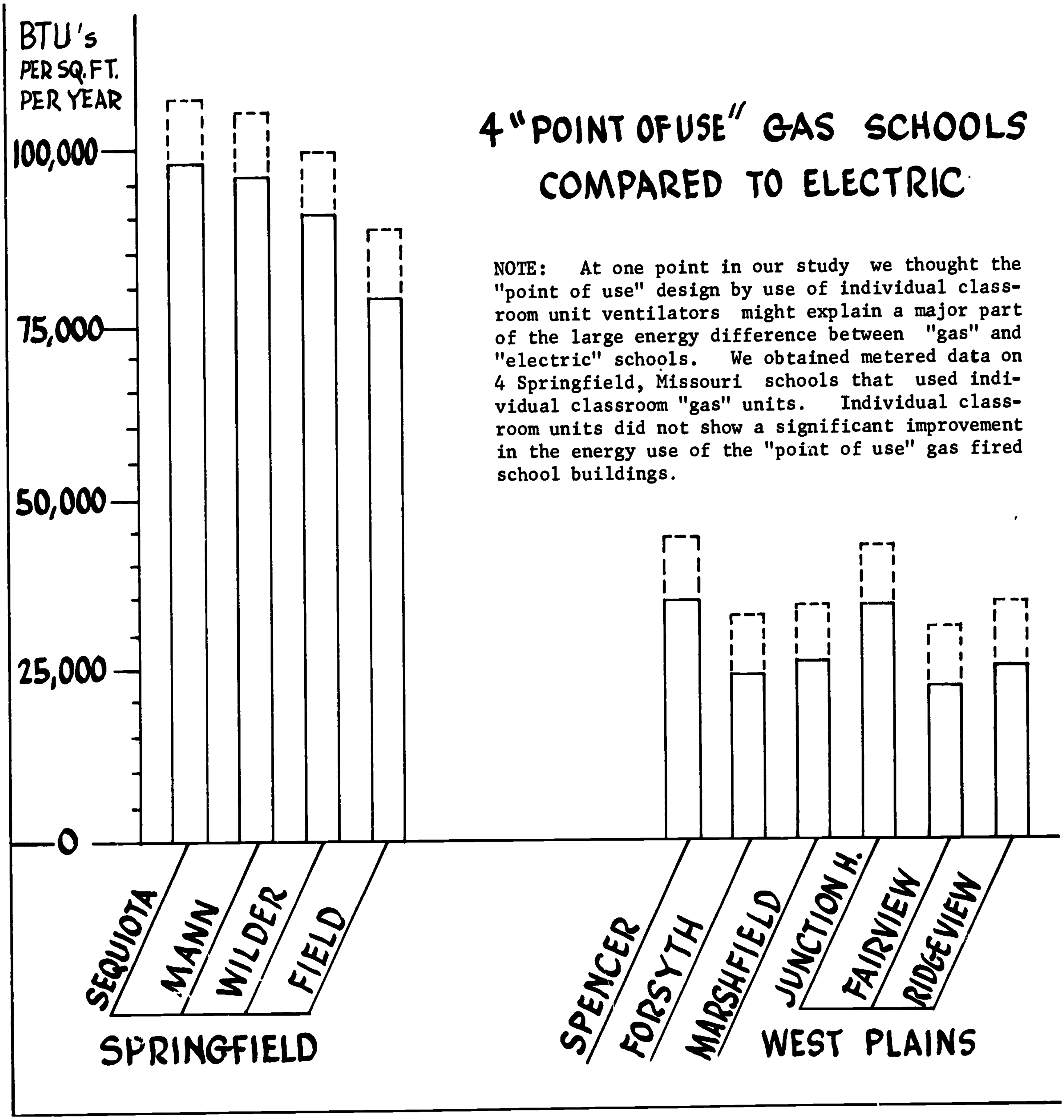
Degree Days	City & State	School	Type	Heating and Water Heating BTU/Sq.Ft./Year	General Power Use KwH	BTU	Total Energy BTU
4,700	Joplin, Mo.	1. McKinley	Elem.	101,000	2.49	8,496	109,496
		2. Eastmoreland	Elem.	105,000	3.67	12,522	117,522
		3. North Junior	Jr.Hi.	102,000	2.85	9,724	111,724
		4. Senior High	Sr.Hi.	60,000	2.38	8,121	68,121
4,700	Springfield, Mo.	5. Eugene Field (L)	Elem.	78,800	2.50 E	8,530	87,330
		6. Wilder (S)	Elem.	90,800	2.50 E	8,530	99,330
		7. Mann (S)	Elem	96,200	2.50 E	8,530	104,730
		8. Sequiota (L)	Elem.	96,800	2.50 E	8,530	105,330
4,888	Kansas City, Mo.	9. Nowlin	Jr.Hi.	99,470	3.75	12,795	112,265
4,888	Johnson Co., Kansas	10. Shawnee Mission So.	Sr.Hi.	29,640E (A.C. 4150)	4.52 E	15,422	45,062
4,888	Kansas City, Mo.	11. Richardson	Elem.	26,900	3.04	10,372	37,272
4,888	Kansas City, Kan.	12. Fairfax	Elem.	30,595	2.00 E&S	6,824	37,419
		13. Bryant	Elem.	86,000	1.67	5,698	91,698
		14. Emerson	Elem.	24,590	2.00 E&S	6,824	31,414
		15. Willard	Elem.	106,500	1.10	3,753	110,253
4,700	West Plains, Mo. (Rural)	16. Junction Hill	Elem.	33,809	2.50 E&S	8,530	42,339
		17. Fairview	Elem.	22,650	2.50 E&S	8,530	31,180
		18. Ridgeview	Elem.	26,302	2.50 E&S	8,530	34,832
4,700	Marshfield, Mo.	19. Marshfield	Elem.	25,556	2.50 E	8,530	34,086
4,700	Bolivar, Mo.	20. Leonard	Elem.	75,181	1.53	5,220	80,401
4,700	Galena, Kan.	21. Spencer	Elem.	34,947	2.56	8,735	43,682
4,700	Forsyth, Mo.	22. Forsyth	Elem.	24,225	2.27	7,745	31,970
4,700	St. Louis, Mo.	23. Bayless	Sr.Hi.	26,750	3.76	12,829	39,579
4,571	Wichita, Kan.	24. McCormack	Elem.	51,002	1.82	6,210	57,212
		25. Fairmount	Elem.	155,996	2.32	7,916	163,912
		26. Woodman	Elem.	69,996	4.73	16,139	86,135
		27. Garrison	Elem.	92,515	2.42	8,257	100,772
		28. Adams	Elem.	76,973	2.11	7,199	84,172
		29. Mary Kelley	Elem.	24,416	2.50 E	8,530	32,946
5,046	Booneville, Mo.	30. David Barton	Elem.	127,747	3.10	10,577	138,324
		31. Senior	Sr.Hi.	132,134	1.56	5,323	137,457
4,907	Nevada, Mo.	32. Senior	Sr.Hi.	96,210	3.60	12,283	108,493
4,871	Sedalia, Mo.	33. Smith-Cotton	Sr.Hi.	90,085	2.51	8,564	98,649
4,907	Clinton, Mo.	34. Senior	Sr.Hi.	101,806	1.80	6,142	107,948
4,907	Lexington, Mo.	35. Senior	Sr.Hi.	113,364	2.50	8,530	121,894
5,046	Jefferson, Mo.	36. Freshman	High Sch.	56,991	1.55	5,289	62,280
		37. Jefferson Sr.	Sr.Hi.	69,943	4.19	14,296	84,239
6,700	Cedar Rapids, Iowa	38. Linn-Mar	El-Sr. Sch.	47,632	1.94	6,619	54,251

Underlined--Electrically Heated
E--Estimated
E&S--Estimated & subtracted from total
AC--Air Conditioning energy included

Degree Days	City & State	School	Type	Heating and Water Heating BTU/Sq.Ft./Year	General Power Use KwH	BTU	Total Energy BTU
6,700	Cedar Rapids, Iowa	39. Linn-Mar	Jr.Hi.	27,565	2.50 E&S	8,530	36,095
		40. Linn-Mar	Sr.Hi.	30,158	2.50 E&S	8,530	38,688
		41. Noelridge	Elem.	105,042	2.50 E	8,530	113,572
		42. Hiawatha	Elem.	98,276	2.50 E	8,530	106,806
5,300	St. Joseph, Mo.	43. Mark Twain	Elem.	128,557	1.06	3,617	132,174
		44. Hall	Elem.	94,034	1.69	5,766	99,800
4,000	Cape Girardeau, Mo.	45. Alma Schrader	Elem.	106,240	2.14	7,302	113,542
		46. Central	Sr.Hi.	44,093	2.54	8,666	52,759
4,871	Sedalia, Mo.	47. Heber Hunt	Elem.	76,668	2.53	8,632	85,300
3,700	Supulpa, Okla.	48. Jefferson	Elem.	54,275	2.10	7,165	61,440
3,700	Shawnee, Okla.	49. Will Rogers	Elem.	79,047	1.42	4,845	83,892
		50. Woodrow Wilson	Elem.	95,635	3.16	10,782	106,417
		51. Jefferson	Elem.	103,069	1.55	5,289	108,358
		52. Horace Mann	Elem.	119,041	3.20	10,918	129,951
		53. Senior	Sr.Hi.	74,221	3.22	10,987	85,[illegible]08
		54. Sequoyah	Elem.	91,360	4.04	13,784	105,145
3,800	Enid, Okla.	55. Waller	Jr.Hi.	81,456	4.71	16,070	97,526
3,800	Muskogee, Okla.	56. Goetz	Elem.	82,977	1.42	4,845	87,822
		57. Foreman	Elem.	69,284	2.66	9,076	78,360
3,000	Ardmore, Okla.	58. Northwest	Elem.	69,414	2.68	9,144	78,558
3,700	Fort Smith, Ark.	59. Sutton	Elem.	60,299	2.74	9,349	69,648
		60. Carnall	Elem.	56,092	2.00	6,824	62,916
		61. Orr	Elem.	53,968	2.00	6,824	60,792
		62. Bonneville	Elem.	64,391	3.03	10,338	74,729
4,919	Topeka, Kan.	63. Crestview	Elem.	102,500	2.50 E	8,530	111,030
		64. McCarter	Elem.	120,000	2.50 E	8,530	128,530
		65. Lowman	Elem.	120,000	2.50 E	8,530	128,530
		66. McEachron	Elem.	122,500	2.50 E	8,530	131,030
		67. Lafayette	Elem.	100,000	2.50 E	8,530	108,530
3,600	Hampton, Va.	68. John Cary	Elem.	25,620	2.50 E	8,530	34,150
	Hoyt, Kan.	69. Grade School	Elem.	24,901 (AC 5,375)	4.15	14,160	39,061
6,261	Ludlow, Mass.	70. Senior	Sr.Hi.	18,284	2.50 E&S	8,530	26,914
5,808	Pittsburgh, Pa.	71. St. Henry's	Elem.	23,334	2.50 E&S	8,530	31,864
5,759	Olympia Fields, Ill.	72. Senior	Sr.Hi.	21,277	3.50 E	11,942	33,219
6,893	Kimberly, Wis.	73. Senior	Sr.Hi.	16,480	2.50 E	8,530	24,980
6,354	Romeoville, Ill.	74. Parkview	Elem.	30,060	2.50 E&S	8,530	38,590

Underlined--Electrically Heated
E--Estimated
E&S--Estimated & subtracted from total
AC--Air Conditioning energy included

4 "POINT OF USE" GAS SCHOOLS COMPARED TO ELECTRIC



NOTE: At one point in our study we thought the "point of use" design by use of individual classroom unit ventilators might explain a major part of the large energy difference between "gas" and "electric" schools. We obtained metered data on 4 Springfield, Missouri schools that used individual classroom "gas" units. Individual classroom units did not show a significant improvement in the energy use of the "point of use" gas fired school buildings.

ENERGY USE & OPERATING COST FOR AIR-CONDITIONING

GAS COMPARED TO ELECTRIC

(5-TON UNITS EXAMPLE)

1 TON = 12,000 BTU
5 TONS = 60,000 BTU

MAIN UNITS

BRYANT 5-TON GAS AIR-CONDITIONER

CARRIER - G.E. - YORK WESTINGHOUSE, ETC. ELECTRIC AIR-CONDITIONER

5 TONS OF COOLING
60,000 BTU

$$\frac{\text{BTU-GAS} \quad 180{,}000}{\text{BTU-ELECTRIC} \quad 20{,}000} = 9$$

AUXILIARIES

(BOTH UNITS USE ELECTRIC FANS – THE GAS UNIT USES AN ADDITIONAL PUMP MOTOR)

EQUIPMENT

WATTS REQUIRED ON 5-TON GAS UNIT		WATTS REQUIRED ON ELECTRIC UNIT
900 WATTS	← INTERIOR FAN →	700 WATTS
1,125 WATTS	← CONDENSER FAN →	800 WATTS
250 WATTS	← CONDENSER PUMP →	NONE
2,275 WATTS 2¼ KILOWATTS	← TOTAL →	1,500 WATTS 1½ KILOWATTS

COST TO OPERATE FOR 1 HOUR

GAS:

(GAS USED BY MAIN UNIT) × (GAS RATE) + (ELECTRICITY USED BY FANS AND PUMPS) × (ELECTRIC RATE) = COST TO OPERATE 1 HOUR

$$\left(\frac{180{,}000 \text{ BTU}}{100{,}000 \text{ BTU/THERM}} \times 5.4¢ \text{ THERM}\right) + \left(2\tfrac{1}{4} \text{ KwH} \times 2¢/\text{KwH}\right) =$$

$$\left(1.8 \text{ THERMS} \times 5.4/\text{THERM}\right) + \left(2\tfrac{1}{4} \text{ KwH} \times 2¢/\text{KwH}\right) = 14.2¢ \text{ PER HOUR}$$

9.7¢ WORTH OF GAS + 4.5¢ WORTH OF ELECTRICITY = **14.2¢** PER HOUR

ELECTRICITY:

(ELECTRICITY USED BY MAIN UNIT) × (ELECTRIC RATE) + (ELECTRICITY USED BY FANS) × (ELECTRIC RATE) =

$$\left(\frac{20{,}000 \text{ BTU}}{3{,}412 \text{ BTU/KwH}} \times 1\tfrac{3}{4} \text{ KwH}\right) + \left(1\tfrac{1}{2} \text{ KwH} \times 1\tfrac{3}{4}¢/\text{KwH}\right) =$$

$$\left(5.9 \text{ KwH} \times 1\tfrac{3}{4}¢\right) + \left(1\tfrac{1}{2} \text{ KwH} \times 1\tfrac{3}{4}¢/\text{KwH}\right)$$

10.3¢ + 2.6¢ = **12.9¢** PER HOUR